

**METHOD AND APPARATUS FOR PROVIDING DUAL AUTOMATIC GAIN
CONTROL DELAY SETTINGS IN A TELEVISION RECEIVER**

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FIELD OF THE INVENTION

This invention relates to a television receiver capable of receiving analog and digital television signals. In particular, the invention is directed to improving the reception of digital television signals.

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BACKGROUND OF THE INVENTION

In order to facilitate the transition from conventional analog television systems to digital television systems, current television receivers are capable of receiving and processing both analog television signals, e.g., National Television Standard Committee (NTSC) television signals, and digital television signals, e.g.,
15 high definition television (HDTV) signals. FIG. 1 depicts a high level block diagram of a tuner portion 100 of such a television receiver. An exemplary television receiver is disclosed in U.S. Patent Application Serial No. 09/140,257, filed August 26, 1998, which is herein incorporated by reference.

The tuner portion 100 comprises an antenna 102, a radio frequency (RF)
20 tuner 104, an intermediate frequency (IF) module 106 and an automatic gain control (AGC) circuit 108. A RF modulated input television signal is received at the antenna 102 or other input terminal such as a cable television set top box, satellite television set top box and the like. The input television signal may
25 comprise either an analog NTSC television signal or a digital HDTV television signal. The RF tuner 104 tunes the input television signal for a particular channel and down converts the input television signal to an IF television signal. The IF tuner 106 converts the IF television signal into a downstream, baseband television signal. The AGC circuit 108 receives the baseband television signal and derives an AGC control signal coupled to an amplifier in the RF tuner 104.
30 The gain of the RF tuner 104 is adjusted in response to the AGC control signal.

However, the transition from analog television systems to digital television systems requires using additional bandwidth in the existing terrestrial television

spectrum. Each television broadcast station is allocated an additional broadcast channel to transmit the HDTV television signal or multiple standard definition digital signals. This channel requires usage of additional bandwidth over the currently allocated bandwidth utilized to transmit analog NTSC television signals.

5 With these additional channels, the broadcast television signal is more susceptible to cross-modulation and inter-modulation distortion. As such, the television receiver must improve its linearity performance in view of distortion associated with the input television signal.

Therefore, a need exists in the art to improve the reception of television
10 signals.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for processing a received television signal comprising one of a first type of television signal and a
15 second type of television signal. Specifically, the method comprises amplifying said received television signal in response to a control signal. If the received television signal comprises the first type of television signal, the RF amplifier gain changes when said received television signal exceeds a first signal level. If the received television signal comprises the second type of television signal, the RF
20 amplifier gain changes when said received television signal exceeds a second signal level. The second signal level is greater than said first signal level. A concomitant apparatus is also provided. As the first signal level is lower for the first type of television signal, reception of the first type of television signal is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

25 The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 depicts a high level block diagram of a tuner portion of a television
30 receiver capable of receiving both analog and digital television signals; and

FIG. 2 depicts a more detailed block diagram of the tuner portion of FIG. 1 in accordance with the present invention.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION

5 FIG. 2 depicts a more detailed block diagram of the tuner portion 100 of FIG. 1 in accordance with the present invention. Specifically, the RF tuner 104 comprises a first bandpass filter 202, a RF amplifier 204, a second bandpass filter 206 and a mixer 208. The first bandpass filter 202 allows or passes the input television signal within a frequency range defined by a selected television
10 channel. The RF amplifier 204 amplifies the signal level or amplitude of the filtered television signal in response to a control signal, e.g., an automatic gain control (AGC) signal, from an AGC circuit 108. After filtering the amplified television signal with the second bandpass filter 206, the mixer 208 uses a local oscillator to convert the input television signal into an intermediate frequency (IF)
15 television signal. The frequency of the local oscillator is generally dependent on the selected television channel.

 The IF tuner 106 comprises a bandpass filter 210 and an IF amplifier 212. The bandpass filter 210 passes the IF television signal within an IF range. The filtered signal is amplified by the IF amplifier 212 prior to being converted into a
20 baseband television signal using a mixer (not shown). Once the IF television signal is converted into baseband, the television signal is sent downstream for further processing in other portions of the television receiver not shown. The baseband television signal is also coupled to the AGC circuit 108.

 In the context of the present invention, the RF amplifier 204 amplifies the
25 television signal to optimize the trade-off between the signal to noise ratio (SNR) and distortion at the television receiver. The television signal is amplified by adjusting the gain of the RF amplifier in response to an AGC signal from the AGC circuit 108. To achieve an acceptable SNR at the television receiver, the signal level of the amplified television signal, i.e., at the mixer 208 input, must be high
30 enough to overcome the noise figure of the mixer 208 and other downstream circuits. However, the signal level of the amplified television signal must also be

low enough to avoid distortion from the linearity limitation of the mixer and other downstream circuits.

Thus, at low signal levels of the input television signal, the television signal is amplified at the maximum gain of the RF amplifier 204. The signal level of the amplified television signal is increased at maximum gain until reaching an optimal signal level at the mixer 208 input. Once the optimal signal level of the television signal is reached, the gain of the RF amplifier 204 is reduced, in order to maintain this optimal signal level. The signal level at which the gain of the RF amplifier 104 is reduced is the RF AGC Delay Point.

Significant differences exist between analog NTSC and digital HDTV television signals in the SNR required to demodulate and provide noise free video in the television receiver. For the analog NTSC television signal, the output from the tuner portion 100 must have a SNR of at least 50 decibels (dB) to present downstream video with a noise free picture. However, for the digital HDTV television signal, the output from the tuner portion 100 only requires a SNR of greater than approximately 17 dB to present a downstream noise free picture. As such, gain reduction of the RF tuner 104 may occur at a much lower signal level for digital television signals than for analog television signals. Namely, the RF AGC Delay Point for digital television signals can be provided at a much lower signal level than the RF AGC Delay Point for analog television signals.

The cross-modulation and inter-modulation performance of the RF tuner 104 improves when the gain of the RF tuner 104 is reduced. Namely, as the gain of the RF tuner 104 is reduced, a higher input signal level is required to produce a certain level of cross-modulation and inter-modulation distortion. In one such television system, the cross-modulation performance of the RF tuner 104 has been empirically determined to improve at least 1 dB for every 1 dB of reduction in the gain of the RF tuner 104.

To advantageously utilize the lower RF AGC Delay Point of digital television signals, the present invention implements dual RF AGC Delay Points for digital and analog television signals. By implementing a lower RF AGC Delay Point for digital television signals, gain reduction starts at a lower signal level of the digital television signal. As the RF amplifier 204 is operating at a lower gain

for digital television signals, the cross-modulation performance, i.e., the linearity performance of the tuner portion 100 to cross-modulation and inter-modulation distortion, is significantly improved for digital television signals.

Returning to FIG. 2, the AGC circuit 108 receives the baseband television signal and generates an AGC signal coupled to the RF amplifier 204. The AGC circuit 108 implements dual RF AGC Delay Points in accordance with the present invention. Specifically, the AGC circuit 108 comprises a digital IF circuit 214, an analog IF circuit 216 and a switch 218. The AGC signal is provided by the digital IF circuit 214 if the received input television signal comprises a digital HDTV television signal. Alternatively, the AGC signal is provided by the analog IF circuit 216 if the received input television signal comprises an analog NTSC television signal. The AGC signal is routed to the RF amplifier 204 from either the analog IF circuit 216 or the digital IF circuit 218 via the switch 218.

In the context of the present invention, a first reference level, REF. 1, is provided to configure the RF AGC Delay Point of the digital television signal. Once the first reference level, REF. 1, is selected, the digital IF circuit 214 decreases the value of the AGC control signal when the signal level of the amplified input television signal exceeds a first signal level, i.e., the AGC Delay Point of the digital television signal. In response to the decreased AGC control signal, the gain of the RF amplifier 204 is decreased, thereby amplifying the input television signal to a lower level. The gain of the RF amplifier 204 is also increased when the AGC control signal is increased by the digital IF circuit 214.

In a similar manner, a second reference level, REF. 2, is provided to configure the RF AGC Delay Point of the analog television signal. Once the second reference level, REF. 2, is selected, the analog IF circuit 216 decreases the level of the AGC control signal when the signal level of the amplified input television signal exceeds a second signal level, i.e., the AGC Delay Point of the analog television signal. The AGC Delay Point of the analog television signal is generally set higher than the AGC Delay Point of the digital television signal in accordance with the present invention. As with digital television signals, however, the gain of the RF amplifier 204 is decreased in response to the decreased AGC signal, thereby amplifying the input television signal to a lower

level. The gain of the RF amplifier 204 is also increased when the AGC control signal is increased by the analog IF circuit 216.

As a much lower SNR is required to produce a noise free picture from the digital television signal, the RF AGC Delay Point is generally much lower for digital television signals than for analog television signals. In one such television system, the RF AGC Delay Point, e.g., the point where gain reduction would begin, was empirically determined to occur when the signal level of the input television signal is approximately -59 dBm (dBm: decibels referenced to one milliwatt) for digital HDTV television signals. In contrast, the RF AGC Delay Point was empirically determined at approximately -49 dBm for analog NTSC television signals. Thus, the tuner portion 100 initiates gain reduction approximately 10 dB earlier for digital television signals.

In another embodiment of the present invention, the gain of the RF tuner 104 can be dynamically reduced based upon an estimate of the input television signal. By dynamically reducing the gain of the RF tuner 104, the linearity performance of the tuner portion 100 is improved when terrestrial digital television signals are received in the presence of adjacent channel interference. Specifically, in order to choose the best compromise between noise and linearity performance, the gain of the RF tuner 104 can be dynamically adjusted based upon an estimate of the amplitude or signal level of the desired and interfering input signal levels. The estimate of the input signal level is determined by measuring voltage level of the control signal, e.g., the RF AGC signal, using an aligned AGC Delay Point and a predetermined tuner gain curve.

Although various embodiments which incorporate the teachings of the present invention have been shown and described in detail herein, those skilled in the art can readily devise many other varied embodiments that will still incorporate these teachings.